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ON THE SENSIBILITY TO LIGHT OF BROMIDE OF SILVER WITH RESPECT TO THE SO-CALLED CHEMICALLY INERT COLOURS.

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WITH regard to certain colours (red, yellow, and green) the photographic action, as we are aware, is either very limited or altogether wanting. This circumstance not only throws difficulties in the way of copying coloured objects (oil paintings), but also with regard to taking portraits, in which coloured clothes and likewise a yellow tint of the complexion, light hair, or rosy cheeks are reproduced in abnormal conditions. What is of a light colour, when of a yellowish tint, comes out bright; and this drawback is only to be got over to a certain extent by a subsequent retouching of the negative.

This abnormal insensibility to colour, as regards photographic plates, is pronounced in the most marked manner with respect to the colours of the spectrum, wherein beyond the violet a powerful action is manifested, which in the visible spectrum (according to the researches hitherto made) does not extend deeper than to the line E in the green. (See Dr. Schultz-Sellack, 'Reports of the German Chemical Society,' 1871, p. 211). Researches recently instituted by me by means of bromide of silver, however, have shown that the sensibility of this preparation not only embraces a considerably wider extent of the spectrum, but even that, by the employment of certain accessories, its sensibility may be carried as far as into the red, or, in other words, to regions where hitherto for photography dark night reigned.

I received recently from England some dry bromide-of-silver plates which Wortley prepares in that country for sale, by a pro-

* From Poggendorff's *Annalen*, vol. cl. p. 453.

cess which is only in part divulged. On exposing these plates to the spectrum, I found to my astonishment that they proved to be more sensitive in the green (that is to say, near the line E) than in the light blue (that is to say, near the line F). Here was an instance of sensibility not in accordance with our previous experience—namely, that a colour the chemical action of which was held to be weak, proved more energetic than that of one which was looked upon as powerful. This circumstance induced me to enter at once upon a more intimate examination of the behaviour of bromide of silver with regard to the colours of the spectrum.

I formed my spectrum by the use of a photographic camera and a Steinheil lens, which I adapted to the battery of prisms of a direct-vision spectroscope. The width of the slit was 0·25 millim. The solar rays were thrown on to it by means of a Foucault's heliostat, for the use of which I am indebted to the great kindness of my friend Dr. Zenker. The length of the spectrum from D to G was 35 millims.

When desirous of comparing my experiments, I chose the time from 11 till 2, and then operated only when there was a cloudless sky, which it is true is but seldom the case at this period of the year. The time of exposure lasted generally ten minutes. The plates were developed with protosulphate of iron. Even in my earliest experiments I found that the sensibility of the bromide of silver extends considerably further than is stated by Dr. Schultz-Sellack, who obtained therewith an action only from the ultra-violet as far as nearly to the line F in the blue. In my experiments the sensibility extended in all cases beyond the line F, more or less far beyond according to the transparency of the atmosphere. Upon this latter point I purpose entering more at length in a separate communication.

I made a trial of the bromide of silver in two forms:—first, as a so-called *wet plate*, that is to say, when moist from an adhering solution of nitrate of silver derived from the silver-bath wherein the plates were sensitized; secondly, as a *dry plate*, obtained by washing off the solution of silver and then drying the plate. (For further details see 'Reports of the German Chemical Society,' 1873, p. 89.) The behaviour of the two classes of plates was different.

The result was that dry bromide of silver exhibits a more extended sensibility for colours than does the bromide which lies beneath a silver solution; when an *acid* development was employed, the latter manifested sensibility up to the middle point between D and E—that is to say, nearly up to the yellow; the former, however, exhibited sensibility 2 millims. beyond the line D, or up into the orange.

The action of the two plates was moreover very different in a qualitative sense. With moist bromide of silver an extremely energetic action is seen between G and F (in the indigo and blue); near F, however, it declines suddenly, and nothing but a faint indication could be traced as far as the other side of E. Dry plates, on the other hand, exhibited a far less decided action in the blue than the wet plates did; this action, however, declined only gradually, and it extended, as has been remarked above, as far as beyond D.

Hence dry bromide of silver is more sensitive for the rays of lesser refrangibility in the visible solar spectrum; moist bromide of silver is most sensitive for the blue rays of greater refrangibility.

For ordinary photographic plates a solution of silver acts as a powerful "sensitizer" (see the above work, 1873, p. 88); that is to say, it augments their sensibility in consequence of its fixing chemically the iodine or bromine as it becomes liberated during exposure. That this action occurs chiefly in the blue finds its solution without doubt in this, namely that the blue rays are more eagerly absorbed by the wet film than are the others.

As has been already observed, the sensibility of the dry bromide of silver diminishes gradually from the blue to the red. With bromide-of-silver plates as prepared by me I could see nothing of the phenomenon which I had noticed as occurring in such a marked manner with the English bromide-of-silver plates spoken of above, namely a falling off of the sensibility from the violet to the blue, and an increase thereof from the blue to the green. The explanation above offered as to the action of nitrate of silver upon bromide of silver induced me, however, to conjecture that the English bromide-of-silver plates must contain some substance *that absorbs the green in a greater measure than the blue.* It is not unusual to give dry plates a coating of substances of the most varied kinds, such as gallic acid, caffeine, or morphine, all which bodies fix iodine and bromine and exercise a sensitizing action; occasionally, too, a yellowish colouring-matter is added thereto, with the view of retarding the "chemical" blue light thereby. The optical demeanour of these "preservatives" may be looked upon as a matter not yet in any way understood; neither, indeed, is their favourable influence placed beyond all question.

The plates of Wortley contain nitrate of uranium, gum, gallic acid, and a yellow colouring-matter as a coating. In order to ascertain whether this coating exercised any action, I washed one of these plates with alcohol and water, and obtained in fact by so doing a plate that no longer gave any indication of an augmented sensibility in the green. I now made an attempt to

impregnate bromide of silver with a substance that absorbs especially the *yellow* rays and fixes free iodine or bromine, in the hope of thereby heightening the sensibility for yellow. I selected coralline, which Professor Liebermann most kindly placed at my disposal. A solution thereof, when greatly diluted, gives in the spectroscope an absorption-band between D and E; in a more concentrated solution the absorption becomes widened out until it reaches beyond D, while, on the other hand, the blue near F is transmitted to a pretty considerable amount.

I dissolved coralline in alcohol and added some of it to my bromide collodion, so that it became of a strong red colour. Dry bromide of silver plates prepared with this collodion were of a decided red tone. On exposure to the spectrum they bore out my anticipation; that is to say, *the plates proved sensitive in the indigo, from there their sensibility decreased till the light blue, became weak at* F, *then increased again, and in the yellow was found to be almost as efficient as in the indigo.* Thus a method was attained for preparing bromide-of-silver plates that are acted upon almost as strongly by a colour hitherto held to be chemically inert, namely yellow, as they are by indigo, which hitherto has been held to be the colour possessing the strongest chemical energy.

After this experiment I was justified in hoping that some other bromide-fixing substance endowed with a powerful absorption of the *red* would in like manner heighten the sensibility of bromide of silver for red. Such a body I met with among the green aniline products. The body in question absorbed in a marked manner the red rays in the middle between D and C; when further concentrated this absorption became extended towards D, while the yellow, green, and blue were transmitted almost unimpaired. In point of fact a collodion coloured with this green proved sensitive to light *as far as into the red.*

The sensibility fell off from the indigo to the yellow, then increased again; and at the identical place where the above-mentioned absorption-band was visible a powerful action in the red was manifested.

From these experiments I think I am pretty well justified in inferring that we are in a position to *render bromide of silver sensitive for any colour we choose*—that is to say, to heighten for particular colours the sensibility it was originally endowed with. To effect this, all that is required is to add thereto some substance which promotes the chemical decomposition of the bromide of silver and absorbs the particular colour in question but not the others. Perhaps we may even arrive at this, namely photographing the ultra-red as we have already photographed the ultra-violet. The photographic inefficiency of certain colours,

which has hitherto proved so great an obstacle, would in that case be surmounted. The following experiment shows to what extent this is practically substantiated. A photograph was taken of a band of blue upon a yellow ground. Employing an ordinary collodion plate with iodide of silver, I obtained thereupon a white band upon a black ground. On a bromide-of-silver and collodion plate, where the action of the blue and the yellow is equally powerful, it was to be anticipated that no effect was to be obtained. I therefore placed in front of the object-glass a disk of yellow glass, which absorbed the blue light and transmitted the yellow unimpaired; and then, after an exposition of suitable duration, I obtained in point of fact a dark band on a light ground.

The matter is not alone of practical but also of scientific interest. Hitherto it has been held that the haloid salts of silver were modified chemically only by the rays which they absorb to a marked extent (Schultz-Sellack, 'Reports of the German Chemical Society,' 1871, p. 211); and, moreover, the influence of "sensitizers" has been partially called in question (Schultz-Sellack, 'Photographic Communications,' seventh annual publication, p. 301).

My investigations show that, with respect to the sensibility of photographic plates to the action of light, not only does the optical aptitude for absorption on the part of the sensitive silver salts themselves, but also the optical aptitude for absorption on the part of the substances mixed therewith play a prominent part.

Further experiments on this point are in progress.

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